RADIATION DAMAGE IN OPTICAL FIBERS AND ATTENUATION OF THE HF SIGNAL

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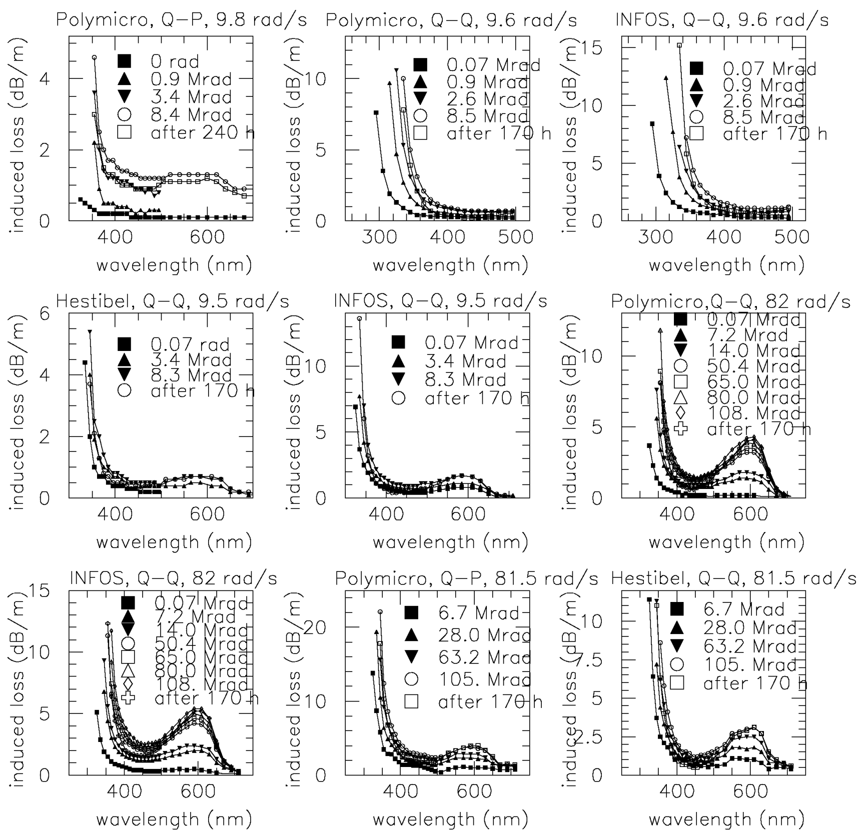
Summary of Measurements



Samples irradiated in Snezhinsk

- Co^{60} γ-source
- Two modes of irradiation
  - 0-10 Mrad @ dose rate ~10 rad/sec
  - 0-100 Mrad @ dose rate ~80 rad/sec

Sample	Dose rate *rad/sec*	Max dose *rad*
PolymicroQP	9.8	$8.4 \cdot 10^6$
PolymicroQQ	9.6	$8.5 \cdot 10^6$
Infos QQ	9.6	$8.5 \cdot 10^6$
Hestibel QQ	9.5	$8.26 \cdot 10^6$
Infos QQ	9.5	$8.26 \cdot 10^6$
Polymicro QQ	82.0	$1.08 \cdot 10^8$
Infos QQ	82.0	$1.08 \cdot 10^8$
Polymicro QP	81.5	$1.05 \cdot 10^8$
Hestibel QQ	81.5	$1.05 \cdot 10^8$

Data Representation

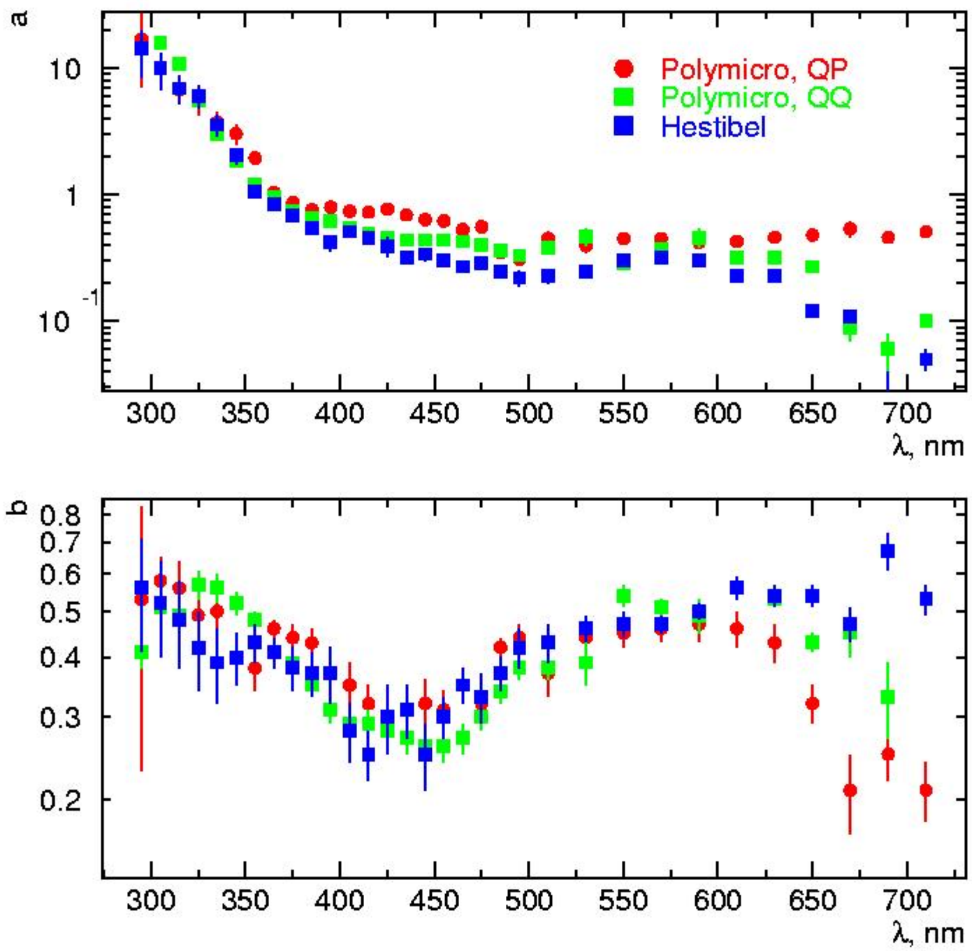
Data were combined as dose dependencies for each λ, used in measurements, and then fitted to a power law including as many points as possible *(in some cases low and high rate data were incombatible)*

$$A(\lambda)=a(\lambda)\cdot D^{b(\lambda)}$$

A–attenuation (in *dB/m*)
D– Dose (in *Mrad*)

- *a(λ)* – attenuation spectrum @ 1Mrad
- *b(λ)* – attenuation rate for different fibers

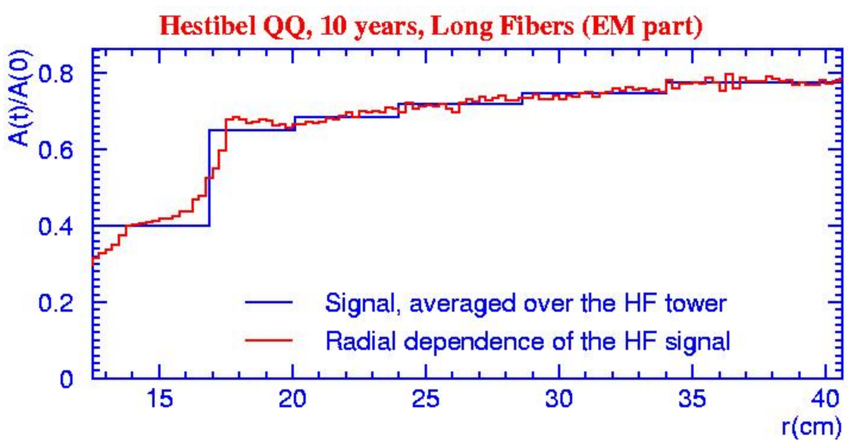
Dependencies are smooth and values of *a(λ)* and *b(λ)* can be interpolated



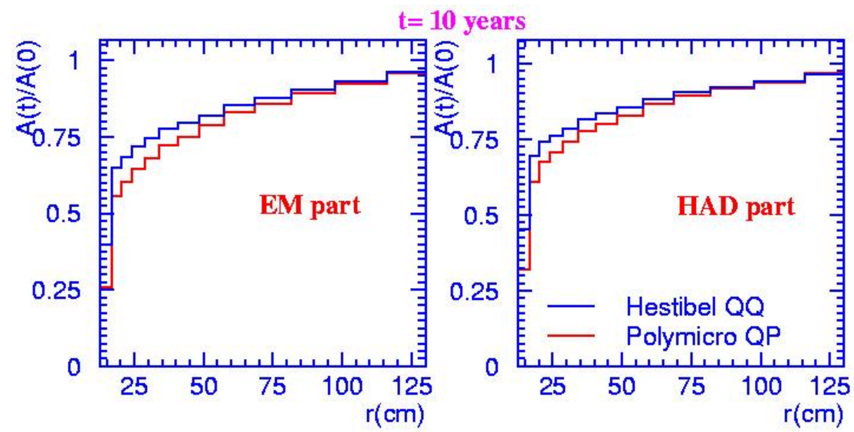
Quartz-Quartz vs Quartz-Plastic

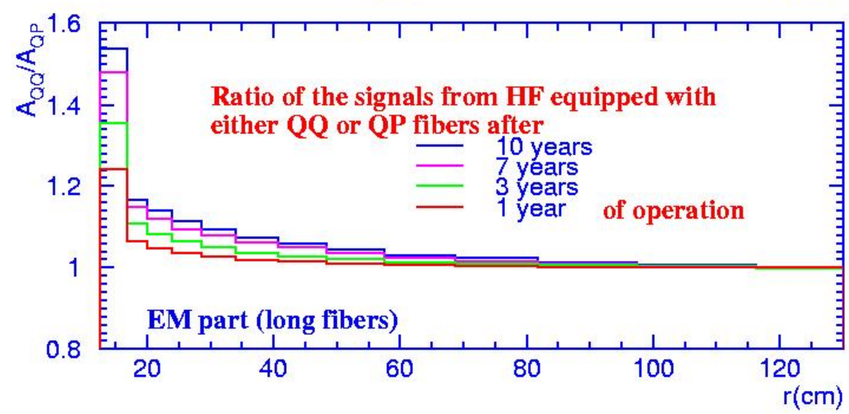
- **3K of Minimum Bias events – 700K p.e.**
- **CMSIM121**
- **HF response with the shower library**

Signal was then attenuated with parameters for Hestibel quartz-quartz and Polymicro quartz-plastic fibers



Attenuation changes by a factor of ~2 within the 1st tower ⇒ extra shift in average η calculated from the tower number.



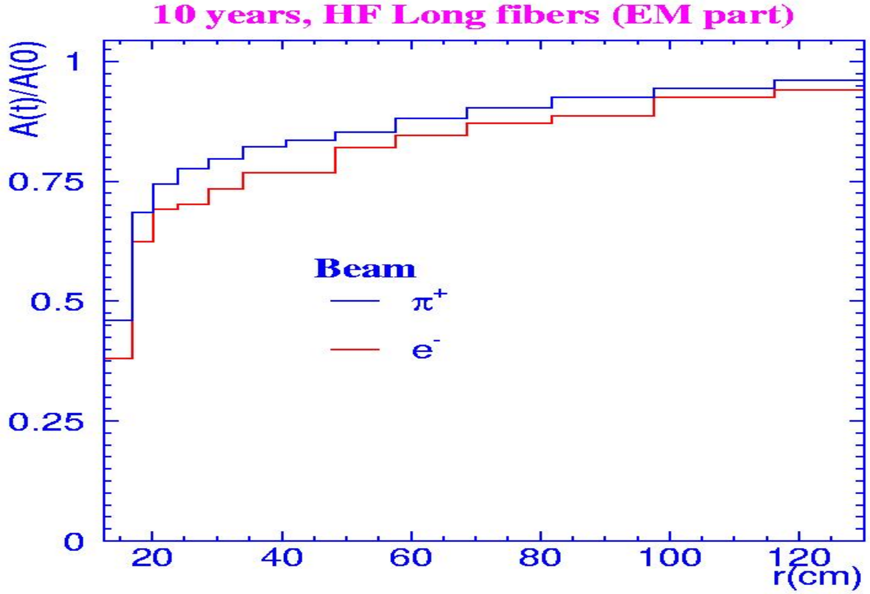


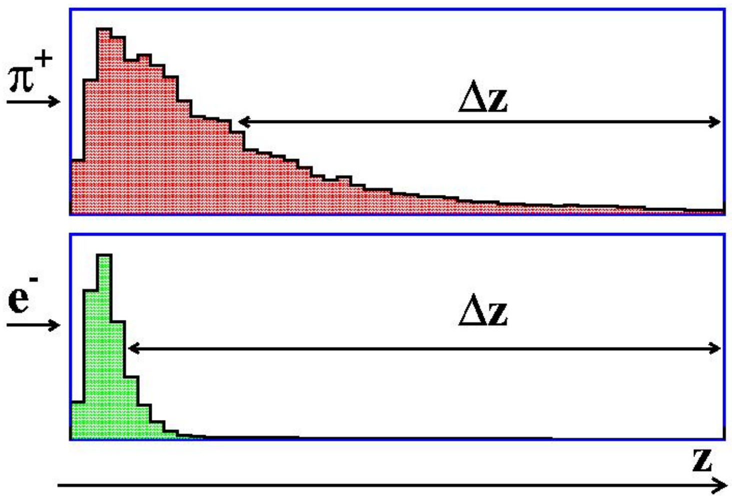
The quartz-quartz fibers are needed for the central tower(s?). The difference is rather insignificant for the rest of the HF.

Corrections for electromagnetic and hadronic showers

Different depth for electromagnetic and hadronic showers ⇒ different radiation damage corrections. This difference can serve as an estimate of the uncertainty introduced by the unknown (model dependent) composition of the jet.

- Electrons and pions; 200K events each
- CMSIM121
- HF with the shower library
- Radiation damage parameterization for Hestibel quartz–quartz fibers





There is the difference... But how big it is ?

Corrections for electromagnetic and hadronic showers(continued)

Let's denote as $E^{(\pi)}$ and $E^{(e)}$ the energy reconstructed with radiation damage corrections from pion and electron beams.

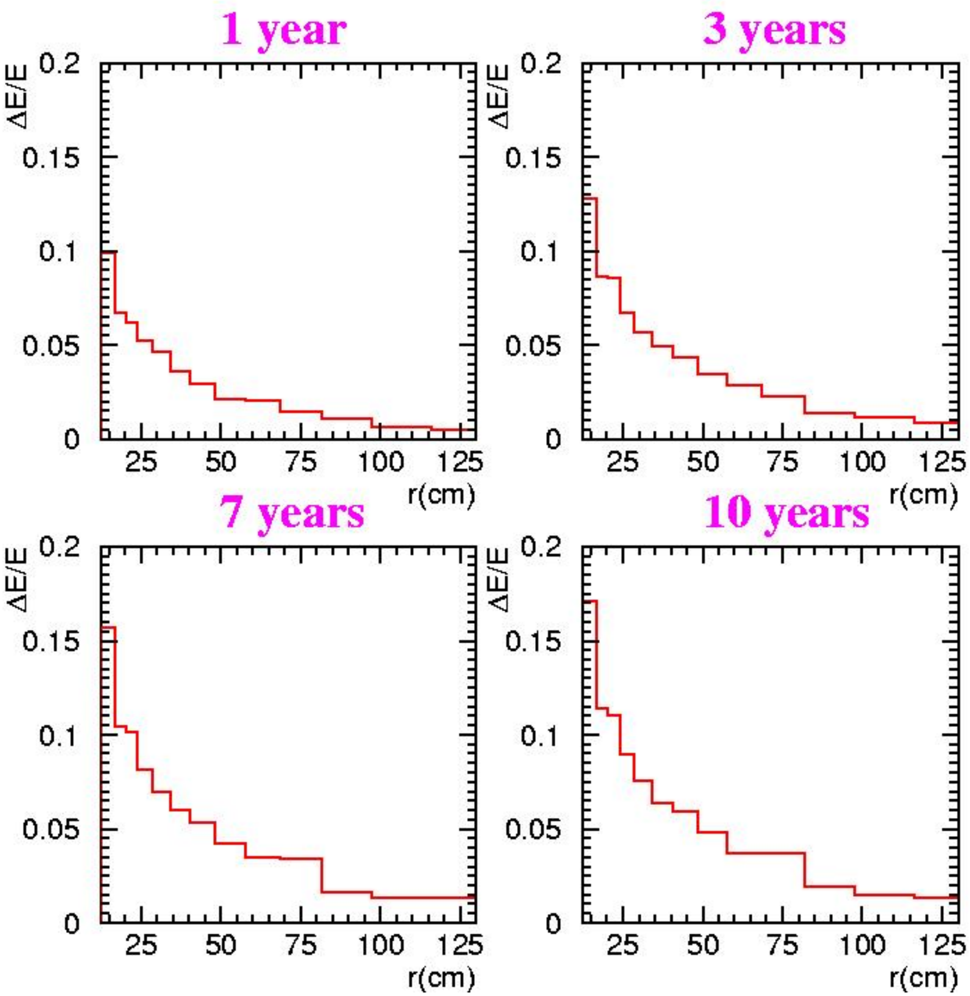
$$E^{(\pi)} = \frac{E_{measured}}{c^{(\pi)}} \qquad E^{(e)} = \frac{E_{measured}}{c^{(e)}}$$

Then $$\frac{\Delta E}{E} = \frac{E^{(e)} - E^{(\pi)}}{E^{(e)}} = \frac{c^{(\pi)} - c^{(e)}}{c^{(\pi)}}$$

will be upper estimate of uncertainty, introduced by the unknown composition of the jet.

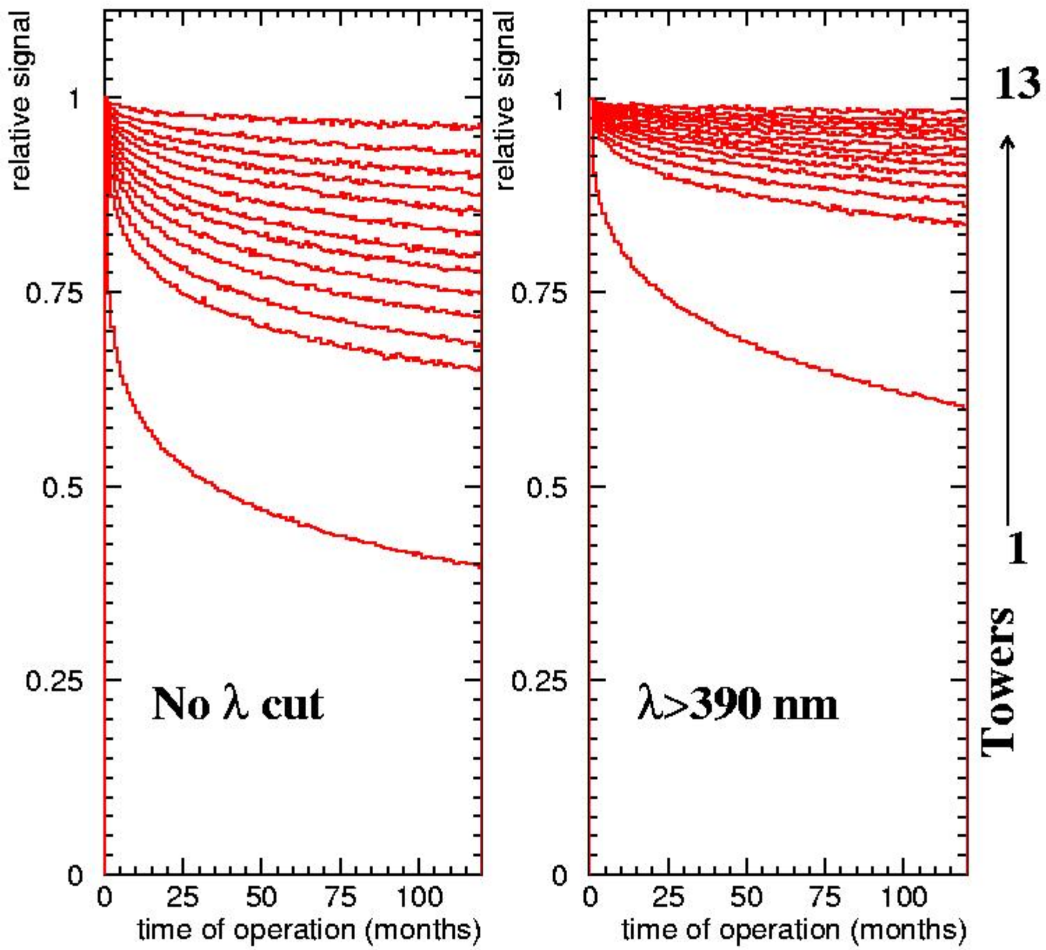
For towers > #3 (η<4.552), this uncertainty does not exceed 10% for all time of the HF operation.

MB events can be used at least as a first order radiation damage correction.



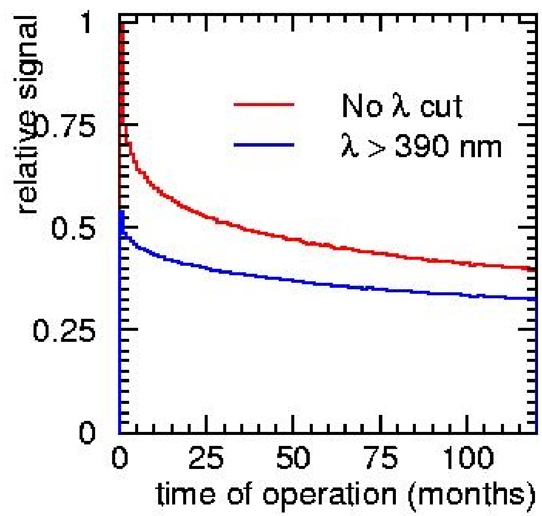
HF Signal vs Time of Operation

- Minimum bias events
- Attenuation parameters for Hestibel quartz–quartz fibers



Tower #1 looses ~25% of its signal during the 1st month of operation.

Wavelength filter (λ>390 nm) improves stability, but kills ~30% of the signal .



Conclusions

- The quartz-quartz fibers show less radiation damage, compared to quartz-plastic ones. Combination of quartz-quartz (for the central tower(s?)) and quartz-plastic fibers is needed for the best performance of the HF.
- The minimum bias events can be used for monitoring of the HF performance and for calculation of the radiation damage corrections (at least the corrections of the first order).
- Close monitoring/recalibration is most needed at the beginning of operation, when the HF signal changes faster.
- The wavelength filters can be used for the central towers. The improvement in stability for other towers does not compensate ~30% losses in the HF signal.

UNCERTAINTIES

- ✔ The conclusions heavily depend on the results of irradiation measurements with γ-source. Radiation damage from hadrons can be different.
- ✔ Higher radiation damage rate from hadrons can increase the difference between corrections for electrons and pions, as well as the dynamics of the behaviour of the HF signal with the time of operation.
- ✔ The results for the 2nd and 3rd towers depend on the beam pipe shape (is it final?).